CHAPTER IV
ANALYSIS METHODS

The overall approach for estimating the nitrogen load reduction and cost per pound of nitrogen load reduced is summarized in Figure IV-1. The analysis began with an estimated NO_x emission reduction for a source-region. The reduction in nitrogen atmospheric deposition was then estimated for each basin based on the ratio of nitrogen atmospheric deposition to NO_x emissions. These ratios are based on RADM summaries that were developed for various source-regions. After the nitrogen atmospheric deposition was estimated, the nitrogen load reduction attributable to each basin was estimated based on the relationship between nitrogen load delivered to Bay tidal waters and nitrogen atmospheric deposition developed from CBWM estimated values. The delivered nitrogen load was summed across all basins to estimate the total reduction in Chesapeake Bay nitrogen load. The total nitrogen load reduction was then combined with associated annual costs to estimate the cost per pound of delivered nitrogen load reduced.

Integral to the overall approach for estimating the nitrogen load reduction due to the control of NO_x air pollution sources is the relationship between NO_x emissions and nitrogen atmospheric deposition, and the relationship between nitrogen atmospheric deposition and delivered nitrogen load. The relationship between emissions and deposition is based on output from RADM. The relationship between deposition and load is based on output from the CBWM. Adjustments are also made to account for the difference between the RADM (modeled) deposition and the 1984-1991 average deposition used in the Watershed Model. This chapter examines the relationships based on RADM and the CBWM output. Throughout this chapter, the term load refers to nitrogen loads delivered to tidal water. (NO_x emission reductions and costs are summarized in Chapter V.)

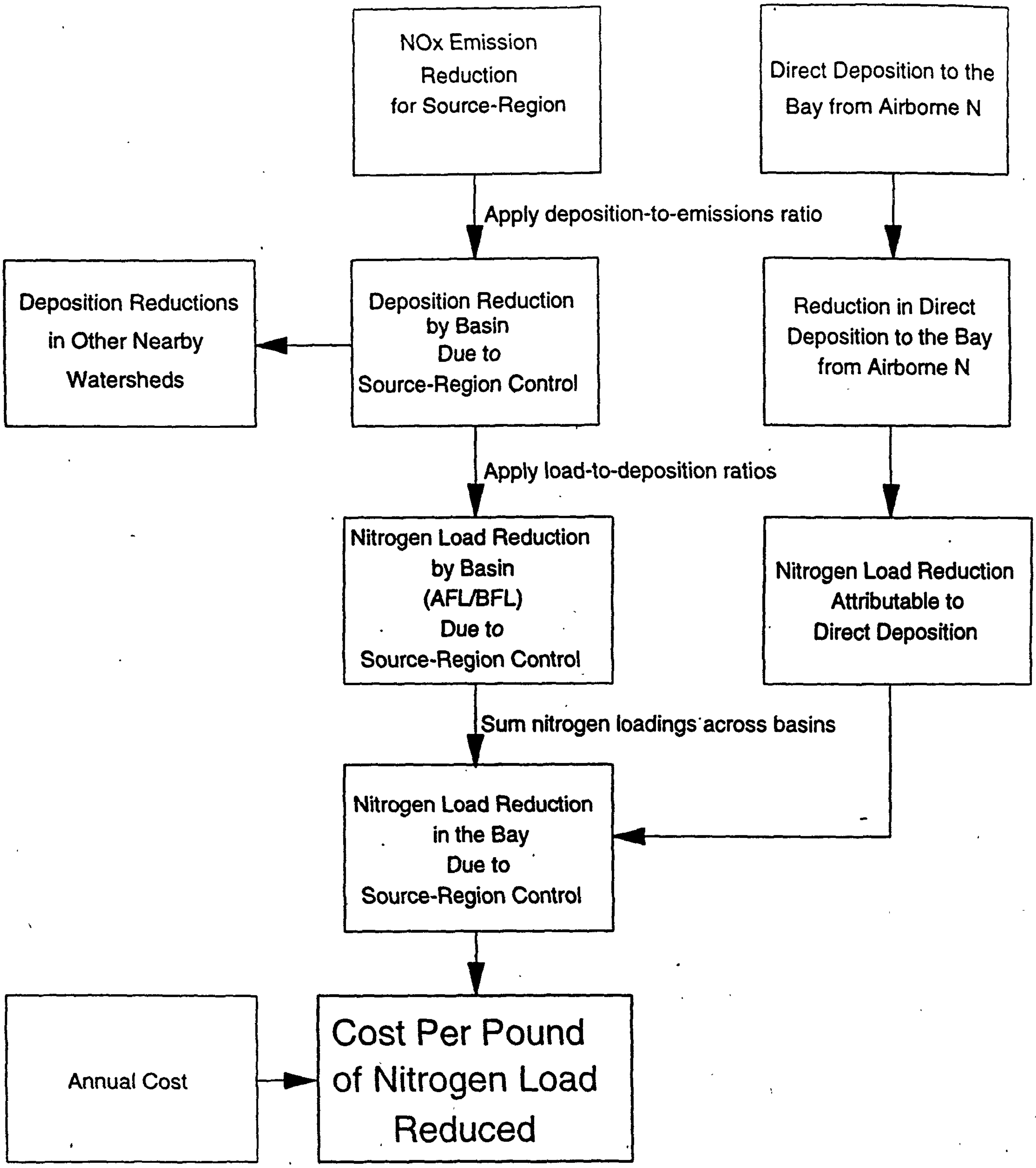
A. LOAD TO DEPOSITION RATIOS

Nitrogen load values for several scenarios were provided from CBWM output. As discussed in Chapter II, the CBWM is divided into model segments representing various land uses and geographic locations. The model segments are aggregated into major basins, both above the fall line (AFL) and below the fall line (BFL).

Scenarios for which nitrogen load summaries (based on output from the CBWM) were provided include:

Reference Scenario: This Scenario was based on the existing watershed conditions of hydrology, land use, point source, and atmospheric loads for the period from 1984 to 1987. The Reference Scenario accounts for all point source, non-point source and atmospheric loads to the basin. The Phase III Reference Scenario loads were reported as the average for the period from 1984 to 1987, which defines the Chesapeake Bay Program average non-point source nutrient load. The average loads for the entire calibration period from 1984 to 1987 were also calculated for all major fall lines.

Figure IV-1
Calculation of Cost of Reduction in Nitrogen Load



CMM Scenario: This Scenario was based on the conditions of implementation of the Clean Air Act Amendments (CAAA) of 1990 applied to the Phase III Reference conditions of hydrology, land use and point source loads. Reductions of nitrate atmospheric deposition were calculated by the RADM model for the conditions of the CAAA implemented throughout the RADM domain of eastern North America. The emissions data used by RADM for the CAA scenario are documented in the report *Regional Oxidant Modeling of the 1990 Clean Air Act Amendments: Default Projection and Control Data* (Pechan, 1994d). Emission controls from Title I, Title II, and Title IV of the CAAA are included in this scenario. BFL loads are reported as 1984-1991 averages, and AFL loads are reported as 1984-1987 averages.

OTC Scenario: This scenario corresponds to Scenario C2, and is based on emissions reflecting implementation of the OTC-LEV petition and the Stationary Source NO_x Initiative. The OTC scenario is applied to the base case conditions of hydrology, land use, and point source loads. Reductions of nitrate atmospheric deposition were calculated by the RADM model. BFL loads are reported as 1984-1991 averages, and AFL loads are reported as 1984-1987 averages.

No Air Scenario: This scenario is based on base case conditions for hydrology, land use, and point source loads, with the complete elimination of atmospheric inorganic (nitrate and ammonia) nitrogen deposition.

Table IV-1 shows the atmospheric nitrate deposition estimates by watershed basin for the reference case (1984 to 199 1 averages). This table shows that the recent historical nitrate deposition in the Chesapeake Bay watershed ranges from a high of 9.4 kg/hectare/year in the Susquehanna basin to a low of 6.6 kg/hectare/year in the southernmost portions of the Bay watershed. In addition to reference case values, Table IV-1 also indicates how the atmospheric nitrate deposition would be expected to change by basin with the NO_x emission reductions that might occur with expected CAA controls by 2005, and the OTC control initiatives in that year.

The Chesapeake Bay Watershed Model - Phase III scenario run results are presented in Table IV-2. The delivered nitrogen load values take into account all transport losses and represent total load to the Bay for each basin. This table shows the importance of the Potomac and the Susquehanna basins in delivering nitrogen to the Bay. The AFL Susquehanna nitrogen loads in the *Reference Scenario* are 35 percent of the Bay Total. The AFL and BFL Potomac combined contributes over 20 percent to the total nitrogen loading to the Bay.

The total nitrogen load from atmospheric deposition (in thousands of lbs) is shown by Chesapeake Bay Basin in Table IV-3. The No Air Scenario was subtracted from the *Reference Scenario* to determine the load due to atmospheric deposition. The resultant nitrogen load value is assumed to represent the atmospheric inorganic nitrogen occurring as a result of deposition. The percentage of the total nitrogen that is attributable to atmospheric deposition is shown for each basin.

In order to examine the relationship between load and deposition, a few of the Chesapeake Bay Watershed Model basins were combined to match the basin definitions used in RADM. The AFL Mattaponi and AFL Pamunkey basins were combined to form the AFL York basin. The BFL Eastern Shore of Maryland was assumed to be equivalent to the BFL Upper Eastern. The BFL Eastern Shore of Virginia was assumed to be equivalent to the BFL Lower Eastern. The BFL York, Western Shore Maryland, and Western Shore Virginia were combined to form the BFL West Chesapeake. This information is summarized in Table IV-4.

Table IV-1
Nitrate Deposition in Reference Case, Clean Air Act, and OTC Scenarios (kg/hectare/year)

Chesapeake Bay Basin	**Reference 1984-1991 Average Wet Plus Dry Nitrate**	**CAA Deposition**	**CAA % Reduction from Reference**	OTC Deposition	OTC % Reduction from Reference
AFL Appomattox	6.67	6.13	8.1%	5.81	12.9%
AFL James	7.28	6.57	9.8%	6.27	13.9%
AFL Patuxent	7.53	6.51	13.5%	5.81	22.8%
AFL Potomac	7.38	6.35	14.0%	5.89	20.2%
AFL Rappahannock	7.56	6.61	12.6%	6.13	18.9%
AFL Susquehanna	9.40	7.90	16.0%	7.01	25.4%
AFL York	7.01	6.27	10.6%	5.77	17.7%
BFL James	6.58	6.12	7.0%	5.82	11.6%
BFL Lower Eastern	6.55	6.01	8.2%	5.61	14.4%
BFL Patuxent	6.72	5.88	12.5%	5.23	22.2%
BFL Potomac	6.87	6.02	12.4%	5.41	21.3%
BFL Rappahannock	6.79	6.07	10.6%	5.51	18.9%
BFL Upper Eastern	7.13	6.26	12.2%	5.63	21.0%
BFL West Chesapeake	7.00	6.20	11.4%	5.63	19.6%
BFL York	6.63	6.08	9.0%	5.68	14.3%

SOURCE: EPA Chesapeake Bay Program Office, August 1996.

Table IV-2
Chesapeake Bay Watershed Model - Phase III Scenario Runs: Delivered Total Nitrogen Loads (1984-1987 Average)[1]

	Total Nitrogen Loads by Scenario (1,000 Ibs):			
Chesapeake Bay Basin	Reference Scenario	CAA Scenario	OTC Scenario	No Air Scenario
AFL Appomattox	1,920	1,892	1,873	1,533
AFL James	13,289	13,187	13,144	12,168
AFL Mattaponi	650	633	620	477
AFL Pamunkey	1,186	1,172	1,162	1,027
AFL Patuxent	2,010	1,970	1,875	1,737
AFL Potomac	31,636	27,477	26,766	16,410
AFL Rappahannock	3,616	3,586	3,473	2,769
AFL Susquehanna	113,578	107,546	104,199	64,876
BFL Eastern Shore MD	26,595	26,253	25,998	23,201
BFL Eastern Shore VA	1,964	1,947	1,936	1,629
BFL James	28,592	28,499	28,442	24,725
BFL Patuxent	2,592	2,555	2,528	1,993
BFL Potomac	33,644	33,509	33,415	30,331
BFL Rappahannock	3,421	3,380	3,346	2,782
BFL Western Shore MD	25,350	25,223	25,144	23,916
BFL Western Shore VA	8,154	8,143	8,134	6,762
BFL York	3,670	3,636	3,612	3,295
Total Watershed Load	301,867	290,608	285,667	219,631

NOTES: [1]AFL load estimates are from Table B (Annual Average Fall Line Nutrient Loads); October 2, 1995. BFL load estimates are from Table A (Average Annual Edge of Stream Loads by Land Use/Load Sauce and Model Segment); February 19, 1996 provided by EPA CBPO.

Table IV-3
Total Nitrogen Load by Chesapeake Bay Basin from Atmospheric Deposition

Chesapeake Bay Basin	Reference Scenario[1] Total Nitrogen Load (1000 lbs)	Nitrogen Load Due to Atmospheric Deposition[2] (1000 lbs)	Percentage of Total Basin Nitrogen Load Delivered to Chesapeake Bay
AFL Appomattox	1,920	387	20%
AFL James	13,289	1,121	8%
AFL Mattaponi	650	173	27%
AFL Pamunkey	1,186	158	13%
AFL Patuxent	2,010	273	14%
AFL Potomac	31,636	15,225	48%
AFL Rappahannock	3,616	847	23%
AFL Susquehanna	113,578	48,701	43%
BFL Eastern Shore MD	26,595	3,394	13%
BFL Eastern Shore VA	1,964	334	17%
BFL James	28,592	3,867	14%
BFL Patuxent	2,592	599	23%
BFL Potomac	33,644	3,313	10%
BFL Rappahannock	3,421	639	19%
BFL Western Shore MD	25,350	1,434	6%
BFL Western Shore VA	8,154	1,392	17%
BFL York	3,670	374	10%
Total Load[3]	324,352	104,721	27%

NOTES: [1]Source: AFL load estimates are from Table B (Annual Average Fall Line Nutrient Loads); October 2, 1995. BFL load estimates are from Table A (Average Annual Edge of Stream Loads by Land Use/Load Source and Model Segment); February 19, 1996 provided by EPA CBPO.
[2]Values represent the difference between the Reference Scenario and the No Air Scenario.
[3]Total percentage load due to atmospheric deposition does not include Bay Surface values.

Table IV-4
Basin Relations between the RADM and Chesapeake Bay Watershed Model Segmentation Schemes

RADM Basin Portions	CBWM Basins	Area (thousand hectares)
AFL Appomattox	AFL Appomattox	350.2
AFL James	AFL James	1,764.0
AFL Patuxent	AFL Patuxent	90.1
AFL Potomac	AFL Potomac	2,994.0
AFL Rappahannook	AFL Rappahannock	415.7
AFL Susquehanna	AFL Susquehanna	7,034.8
AFL York	AFL Mattaponi and AFL Pamunkey[1]	431.3
BFL James	BFL James	474.9
BFL Low Eastern	BFL Eastern Shore of VA	83.1
BFL Patuxent	BFL Patuxent	143.6
BFL Potomac	BFL Potomac	680.0
BFL Rappahannock	BFL Rappahannock	253.4
BFL Upper Eastern	BFL Eastern Shore of MD	1,165.8
BFL West Chesapeake	BFL York, BFL Western Shore of MD, and BFL Western Shore of VA	837.7
Bay Tidal Waters Surface	–	1,040.0

NOTES: [1]The correspondence between RADM Basin portion and CBWM Basin is based on the location of the fall line and the definition of CBWM Basin boundaries.

The percentage reduction in both nitrogen load and nitrogen deposition from the reference data to the *CAA Scenario* and to the *OTC Scenario* is represented in Table IV-5 The nitrogen load data represents the load due to atmospheric deposition only. Reductions are calculated from the reference (or 1990) values. Differences in the proportional reductions between deposition and delivered load are largely due to other loads or processes not accounted for in this analysis. For example, in basins with large water point source loads (e.g., BFL Potomac, BFL James, and BFL West Chesapeake), the delivered load reductions are less than the atmospheric deposition reductions. This is because water point source discharges are not affected by the CAA and OTC reductions. On the other hand, basins with a high portion of forest land use (e.g., AFL Susquehanna and AFL Potomac) have relatively higher delivered CAA and OTC loads. This is because atmospheric deposition of nitrogen is the only nutrient input in forest lands.

B. DEPOSITION-TO-EMISSION RATIOS

Deposition-to-emission ratios were calculated for each of the source-regions provided in the RADM summary data. (The RADM summary data is provided in Appendix A.) The deposition rates were converted to annual values using the estimated area in each basin (or for the Bay surface). Sample values are provided in Table IV-6 for various geographic regions. As shown in this table, sources closest to the watershed have larger ratios and, thus, have a higher impact on deposition and, ultimately, on nitrogen load. The BFL James and AFL Susquehanna basins have the highest load-to-deposition ratios as illustrated in Table IV-6. Thus, NO_x emission controls in geographic areas which have a greater impact on deposition in these basins, as well as areas which have the greatest impact on direct deposition to the tidal Bay itself, will have the greatest effect on reducing nitrogen loads due to atmospheric deposition.

Table IV-5
Percentage Reduction of Nitrogen Load versus Atmospheric Deposition

Basin	CAA Nitrogen Atmospheric Deposition Reduction[1]	CAA Nitrogen Load Reduction[2]	OTC Nitrogen Atmospheric Deposition Reduction[1]	OTC Nitrogen Load Reduction[2]
AFL Appomattox	8.0%	1.4%	13.0%	2.4%
AFL James	10.0%	0.7%	14.0%	1.1%
AFL Patuxent	14.0%	2.6%	23.0%	6.7%
AFL Potomac	14.0%	13.1%	20.0%	15.4%
AFL Rappahannock	13.0%	0.8%	19.0%	4.0%
AFL Susquehanna	16.0%	5.3%	25.0%	8.3%
AFL York	11.0%	1.7%	18.0%	2.9%
BFL James	7.0%	0.3%	12.0%	0.5%
BFL Lower Eastern	8.0%	0.8%	14.0%	1.4%
BFL Patuxent	13.0%	1.4%	22.0%	2.5%
BFL Potomac	12.0%	0.4%	21.0%	0.7%
BFL Rappahannock	11.0%	1.2%	19.0%	2.2%
BFL York	9.0%	0.9%	14.0%	1.6%
BFL Upper Eastern	12.0%	1.3%	21.0%	2.2%
BFL West Chesapeake	11.0%	0.4%	20.0%	0.7%

NOTES: [1]Deposition reductions are based on RADM data as summarized in Table IV-1.
[2]Load reductions represent reductions in load due to atmospheric deposition only and are based on Chesapeake Bay Watershed Model data as summarized in Table IV-2. Reductions are taken from the reference scenario.

Table IV-6
Chesapeake Bay Basin Atmospheric Nitrogen Deposition-to-NO_X Emission Ratios

	Deposition-to-Emission Ratio by Source-Region (lbs-N/tpy-NO_x):				
Chesapeake Bay Basin	**Airshed 1**	**Airshed 2**	**Eastern U.S.[1] & Canada**	**Bay Watershed States[2]**	**Maryland**
AFL Appomattox	1.09	0.97	0.37	1.89	1.69
AFL James	5.49	4.99	1.98	8.17	5.82
AFL Patuxent	0.50	0.42	0.15	1.07	3.38
AFL Potomac	11.07	9.69	3.72	14.81	20.65
AFL Rappahannock	1.24	1.08	0.40	1.94	1.80
AFL Susquehanna	22.39	20.10	8.14	34.18	29.92
AFL York	1.59	1.39	0.52	2.99	3.06
BFL James	1.74	1.50	0.57	3.39	2.84
BFL Lower Eastern	0.18	0.16	0.07	0.26	0.39
BFL Patuxent	0.58	0.48	0.19	1.17	2.89
BFL Potomac	2.88	2.45	0.89	5.80	9.26
BFL Rappahannock	0.88	0.76	0.29	1.70	2.21
BFL Upper Eastern	4.00	3.40	1.30	7.62	21.28
BFL West Chesapeake	4.22	3.53	1.22	8.79	20.30
Bay Surface	3.01	2.58	1.04	5.51	10.89

NOTES: [1]Eastern U.S. includes Delaware, District of Columbia, Kentucky Maryland, New Jersey New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia and West Virginia.
[2]Bay Watershed States include New York, Pennsylvania, Delaware, Maryland, Virginia West Virginia and the District of Columbia.

CHAPTER V
NO_x EMISSION REDUCTIONS AND COSTS

This chapter summarizes the emissions and costs associated with implementation of the CAA Base Case, Scenario C2, and Scenario E for States within the Chesapeake Bay Airshed 2. Total State values are provided; some States are only partially included in the Chesapeake Bay Airshed 2. The annual costs and emission reductions summarized in this chapter were used with the deposition-to-emission ratios and the load-to-deposition ratios (summarized in the previous chapter) to determine the total reduction in nitrogen load and corresponding cost per pound of delivered nitrogen load reduced.

A. NO_x EMISSION LEVELS

NO_x reference (1990) emission levels are summarized by State and source type in Table V-1. Within the States in the OTR emissions are dominated by motor vehicles (41 percent). Utilities are the second highest emitter, accounting for 29 percent of NO_x emissions in the OTR. Outside the OTR, utilities are the largest emitter at 42 percent, followed by motor vehicles at 3 1 percent (EPA, 1993).

NO_x emissions by State and by scenario are summarized in Table V-2. CAA baseline emissions show an expected decrease of 1.05 million tons from 1990 (reference) levels for States within the Chesapeake Bay airshed. This represents an overall decrease of 15 percent. The emission decrease within the OTR is slightly higher at 18.6 percent, compared to 12.7 percent for Chesapeake Bay Airshed 2 States outside of the OTR Scenario C2 shows a 22 percent decrease within the Chesapeake Bay Airshed 2 OTR States relative to the CAA baseline. Outside of the OTR, Scenario E shows a 28 percent decrease in NO, emissions for the 2005 CAA baseline. The overall NO_x reduction for Scenario E (both inside and outside the OTR) is 1.6 million tons, which represents a 26 percent decrease from the 2005 CAA baseline estimate.

B. CAA CONTROL COST ESTIMATES

Total costs on a State-level for the implementation of NO_x-related provisions of the CAA are shown in Table V-3 for the Airshed 2 States. These costs (estimated using ERCAM-NO_x) include RACT provisions in ozone nonattainment areas, Title IV utility NO_x controls, new source review for utilities, Tier 1 tailpipe standards, motor vehicle I/M (one-half of the cost is attributed to NO_x for this analysis), and Federal non-road engine standards for compression ignition engines.

C. SCENARIO C2 AND SCENARIO E CONTROL COST ESTIMATES

Control costs were estimated for utility and non-utility point sources for Scenario C2 and Scenario E using the ERCAM-NO_x model (Pechan, 1994c). Because emission files for 2005 for each scenario were already available, the focus of this analysis was on estimating the annual control cost for each scenario. The costing procedure for stationary sources is detailed following Table V-3.

Table V-1
NO_x Reference (1990) Emission Levels in the Chesapeake Bay Airshed 2 States by Source Category

	NO_x Emissions (thousand tpy)				
State	**Utility**	**Non-Utility Point**	**Area**	**Motor Vehicle**	**Total**
OTR:					
Delaware	24	11	8	23	66
District of Columbia	1	1	8	10	20
Maryland	96	26	63	140	325
New Jersey	55	56	100	188	399
New York	186	71	167	366	789
Pennsylvania	372	83	173	313	940
Virginia (Northern VA)	12	1	22	37	72
OTR States:	746	248	540	1,077	2,611
Outside OTR:					
Kentucky	331	29	132	127	618
North Carolina	162	47	104	230	542
Ohio	523	90	162	330	1,105
Tennessee	192	105	84	170	552
Virginia (w/o Northern VA)	59	61	89	180	389
West Virginia	307	56	42	61	466
Outside OTR States:	1,574	387	612	1,098	3,673
Bay Airshed 2 States:	**2,320**	**635**	**1,152**	**2,175**	**6,284**

SOURCE: EPA, 1993.

Table V-2
NO_x Emission Levels in the Chesapeake Bay Airshed 2 States by Scenario

	NO_x Emissions (thousand tpy):		
State	**1990**	**2005 CAA**	**2005 Scenario C2 and 2005 Scenario E[1]**
OTR:			
Delaware	66	55	41
District of Columbia	20	18	16
Maryland	325	280	217
New Jersey	399	334	279
New York	789	627	516
Pennsylvania	940	747	539
Virginia (Northern VA)	72	64	53
OTR States:	2,611	2,125	1,661
Outside OTR:			
Kentucky	618	523	350
North Carolina	542	512	398
Ohio	1,105	894	617
Tennessee	552	520	383
Virginia (w/o Northern VA)	389	403	347
West Virginia	466	366	200
outside OTR states:	3,673	3,217	2,296
Bay Airshed 2 States:	**6,284**	**5,342**	**3,957**

NOTE: [1]Scenario C2 and Scenario E are listed in one column. Scenario C2 applies the OTC-LEV petition and the Stationary Source NO_x Initiative only to States within the OTR. Thus, total reductions in the airshed for Scenario C2 are represented by the OTR subtotal (emissions for non-OTR States would remain at CAA levels). Scenario E applies both of these control programs to States located both inside and outside of the OTR.

Table V-3
CAA NO_x-Related Control Costs in the Chesapeake Bay Airshed 2 States

State	Cost (million $)
OTR:	
Delaware	34.1
District of Columbia	5.9
Maryland	112.7
New Jersey	122.5
New York	224.2
Pennsylvania	205.0
Virginia (Northern VA)	19.4
OTR states:	723.8
Outside OTR:	
Kentucky	135.7
North Carolina	91.8
Ohio	225.5
Tennessee	85.3
Virginia (w/o Northern VA)	63.1
West Virginia	95.5
Outside OTR States:	696.9
Bay Airshed 2 States:	**1,420.7**

Using the ROM emission projection files, a percentage reduction was calculated for the emission changes reflected in the Base Case CAA, Scenario C2, and Scenario E (Pechan, 1994d). Using ERCAM-NO_x, a control strategy was then assigned to each source, based on the percentage control required to reach the RACT in the Base Case or 0.15 lbs/MMBtu level in Scenario C2 and Scenario E. If none of the control options provided the level of control necessary to match the calculated percentage reduction, the most stringent control available was chosen for costing purposes. ERCAM-NO_x was then used to estimate capital, O&M, and annual costs in 1990 dollars for the chosen control level. Control costs are only assigned to the primary fuel (the fuel with the highest emissions) at a boiler or point This prevents double counting of controls on a single unit. Cost calculations do not allow for emission trading.

Table V-4 presents a cost summary by Chesapeake Bay Airshed 2 States within the OTR by source category. The cost estimates shown in the table represent the incremental cost between the Base Case CAA and Scenario C2. Table V-5 presents the same information for the Chesapeake Bay Airshed 2 States outside the OTR Motor vehicle costs assume a LEV cost of $100 per vehicle and a ULEV cost of $205 per vehicle (Pechan, 1994b). New light-duty gasoline vehicle (LDGV) sales in 2005 were assumed to be 63 percent LEVs and 37 percent ULEVs. No ZEVs were assumed in this analysis. Year 2005 annual costs of the OTC-LEV program are estimated based on projected vehicle sales in 2005. Both cars and light-duty trucks (LDTs) are included in the program. The cost estimates in this analysis for the OTC-LEV program include the total cost of the multi-pollutant LEV standards. However, only the benefit of the NO_x emission standards is included in the emission projections. This likely overstates the costs attributable to NO_x, because the 0.2 gram- per-mile NO_x emission standard is the same for both LEVs and ULEVs. If NO_x control were the only objective of the OTC-LEV program, there would be no reason to require vehicles to meet the ULEV standards (ULEV standards for NMOG and CO are lower than the corresponding LEV standards).

Compared with other EPA-sponsored analyses of the Stationary Source NO_x Initiative, this analysis tends to show higher costs. Potential reasons for higher cost estimates relative to estimates in other studies include the following:

1. All stationary sources within the OTC States, regardless of ownership, have been considered as candidates for control in this analysis (utility and industrial), whereas other EPA-sponsored analyses only considered utilities.

2. Opportunities for cost savings through an emission trading program have not been evaluated here.

3. Some fuel combustors within the OTC states are responding to CAA requirements and market factors by repowering, or installing more control than required during the early to mid-1990s. This analysis assesses the cost of complying with a 0.15 lbs/MMBtu limit from a generic RACT-level baseline (the CAA scenario). Thus, a SCR-type control technology cost is being attributed to some units that may not be installing such controls.

Table V-4
Cost Summary for OTR Chesapeake Bay Airshed 2 States: Cost Increase from Base Case CAA to Scenario C2 (2005) (LEV plus 0.15 lbs/MMBtu NO_x Emission Limit)

	Cost Increase by Source Type (in millions):			
State[1]	**Utility Point Sources**	**Non-Utility Point Sources**	**Motor Vehicle**[2]	**Total**
Delaware	$20.8	$8:8	$6.4	$36.0
District of Columbia	$0.3	$0.4	$3.4	$4.1
Maryland	$62.7	$18.8	$39.0	$120.5
New Jersey	$53.1	4 . 4	$55.5	$113.0
New York	$124.1	$70.0	$94.3	$288.4
Pennsylvania	$214.0	$51.3	$76.4	$341.7
Northern Virginia	$13.8	$0.0	$11.9	$25.7
Total	**$489**	**$152**	**$287**	**$930**

NOTES: [1]Total State values are provided.
[2]Motor vehicle costs assume LEV cost of $100 per vehicle and ULEV cost of $205 per vehicle, with 63 percent of LDGV and LDGT1 new sales in 2005 LEVs and 37 percent of LDGV and LDGT1 new sales in 2005 ULEVs.

Table V-5
Cost Summary for Non-OTR Chesapeake Bay Airshed 2 States: Cost Increase from Base Case CAA to Scenario E (2005) (LEV plus 0.15 lbs/MMBtu NO_x Emission Limit)

	Coat Increase by Source Type (in millions):			
State[1]	**Utility Point Sources**	**Non-Utility Point Sources**	**Motor Vehicle**[2]	**Total**
Kentucky	$192.3	$1.8	$29.7	$223.8
North Carolina	$103.9	$76.5	$58.1	$238.5
Ohio	$293.2	$109.1	$80.7	$483.0
Tennessee	$110.9	$131.1	$43.9	$285.9
Virginia (w/o Northern VA)	$44.1	$22.6	$46.5	$113.2
West Virginia	$157.5,	$58.8	$12.9	$229.2
Total	**$902**	**$400**	**$314**	**$1,574**

NOTES: [1]Total State values are provided.
[2]Motor vehicle costs assume LEV cost of $100 per vehicle and ULEV cost of $205 per vehicle. with 63 percent of LDGV and LDGT1 new sales in 2005 LEVs and 37 percent of LDGV and LDGT1 new sales in 2005 ULEVs.

Tables V-6 through V-13 present the cost of NO_x reductions for each of the following source types: motor vehicles, non-utility point source, and utility point source. Tables V-6 and V-7 show reductions for motor vehicles; the first table presents information for each Chesapeake Bay Airshed 2 State within the OTR, and the second covers the Chesapeake Bay Airshed 2 States outside of the OTR Tables V-8 and V-9 present reductions for non-utility point sources, and Tables V-10 and V-11 show reductions for utility point sources. Tables V-12 and V-13 summarize the per-ton cost of NO_x reductions by State and source type for Scenario C2 and Scenario E, respectively.

Table V-6
Cost of Motor Vehicle NO_x Reductions:
OTR Chesapeake Bay Airshed 2 States

State[1]	NO, Emissions (thousand tpy):[2] CAA Scenario	Scenario C2	Total Annual Cost of NO_x Emission Reductions (in million)	Coat per Ton of NO_x Emission Reductions
Delaware	18.6	16.6	$6.4	$3,200
District of Columbia	8.0	6.8	$3.4	$2,800
Maryland.	108.8	95.2	$39.0	$2,900
New Jersey	141.7	121.1	$55.5	$2,700
New York	263.7	227.1	$94.3	$2,600
Pennsylvania	230.3	206.2	516.5	$3,200
Northern Virginia	29.5	25.1	$11.9	$2,700
Total	**800.6**	**698.1**	**$287.0**	**$2,800**

NOTES: [1]Total State values are provided
[2]CAA Scenario and Scenario C2 NO_x emissions are 2005 estimates.

Table V-7
Cost of Motor Vehicle NO_x Reductions:
Non-OTR Chesapeake Bay Airshed 2 States

State[1]	NO_x Emission (thousand tpy):[2] CAA Scenario	Scenario E	Total Annual Cost of NO_x Emission Reductions (in millions)	Cost per Ton of NO_x Emission Reductions
Kentucky	109.3	105.4	$29.7	$7,600
North Carolina	208.3	200.7	$58.1	$7,600
Ohio	286.5	275.6	$80.7	$7,400
Tennessee	157.2	151.4	$43.8	$7,600
Virginia (w/o Northern VA)	167.5	161.5	$46.5	$7,800
West Virginia	50.0	48.3	$12.9	$7,600
Total	**978.8**	**942.9**	**$271.7**	**$7,600**

NOTES: [1]Total State values are provided.
[2]CAA Scenario and Scenario E NO_x emissions are 2005 estimates.

Table V-8
Cost of Non-Utility Point Source NO_x Reductions:
OTR Chesapeake Bay Airshed 2 States

State[1]	NO_x Emissions (thousand tpy):[2] CAA Scenario	Scenario C2	Total Annual Cost of NO_x Emission Reductions (in millions)	Cost per Ton of NO_x Emission Reductions
Delaware	6.0	5.1	$8.8	$9,800
District of Columbia	0.9	0.8	$0.4	8.100
Maryland	20.5	18.2	$18.8	$8,200
New Jersey	39.5	333	$4.4	$710
New York	52.0	41.6	$70.0	$6,700
Pennsylvania	64.4	59.0	$51.3	$9,500
Northern Virginia	0.3	0.3	$0.0	
Total	**183.6**	**1583**	**5153.7**	**$6,100**

NOTES: [1]**Total** State values are provided.
[2]**CAA Scenario and Scenario C2 NO_x emissions are 2005 estimates.**

Table V-9
Cost of Non-Utility Point Source NO_x Reductions:
Non-OTR Chesapeake Bay Airshed 2 States

State[1]	NO_x Emission (thousand tpy):[2] CAA Scenario	Scenario E	Total Annual Cost of NO_x Emission Reductions (in millions)	Coat per Ton of NO_x Emission Reductions
Kentucky	28.6	283	$1.8	$6,500
North Carolina	56.5	43.2	$76.5	$5,700
Ohio	87.2	69.4	$109.1	$6,100
Tennessee	124.8	98.0	$131.1	$4,900
Virginia (w/o Northern VA)	71.4	67.5	$22.6	$5,800
West Virginia	52.3	42.9	$58.8	$6,300
Total	**420.8**	**3493**	**$399.9**	**$5,600**

NOTES: [1]**Total** State values are provided.
[2]**CAA Scenario and Scenario E NO_x emissions in 2005 estimates.**

Table V-10
Cost of Utility NO_x Reductions:
OTR Chesapeake Bay Airshed 2 States

State[1]	NO_x Emissions (thousand tpy):[2] CAA Scenario	Scenario C2	Total Annual Cost of NO_x Emission Reductions (in millions)	Cost per Ton of NO, Emission Reductions
Delaware	22.8	11.4	$20.8	$1.800
District of Columbia	0.7	0.5	$0.3	$2,100
Maryland	86.4	39.4	$62.7	$1,300
New Jersey	49.9	21.2	$53.1	$1,900
New York	139.8	76.1	$124.1	$1,900
Pennsylvania	273.1	94.9	$214.0	$1,200
Northern Virginia	11.7	4.8	$13.8	$2,000
Total	**584.4**	**208.9**	**$488.8**	**$1,300**

NOTES: [1]Total State values are provided.
[2]CAA Scenario and Scenario C2 NO_x emissions are 2005 estimates.

Table V-11
Cost of Utility NO_x Reductions:
Non-OTR Chesapeake Bay Airshed 2 States

State[1]	NO_x Emission (thousand tpy):[2] CAA Scenario	Scenario E	Total Annual Cost of NO_x Emission Reductions (in millions)	Coat per Ton of NO. Emission Reductions
Kentucky	244.6	75.5	$192.3	$1,100
North Carolina	135.2	42.8	$103.9	$1,100
Ohio	353.5	105.5	$293.2	$1,200
Tennessee	150.9	47.1	$110.9	$1,100
Virginia (w/o Northern VA)	71.0	25.1	$44.1	$1,000
West Virginia	222.3	66.8	$157.5	$1,000
Total	**1,177.4**	**362.8**	**$901.9**	**$1,100**

NOTES: [1]Total State values are provided.
[2]CAA Scenario and Scenario E NO_x emissions are 2005 estimates.

Table V-12
Cost per Ton ($/ton) of NO_x Emission Reductions by State and Source Type: OTR Chesapeake Bay Airshed 2 States

State	Coat per Ton by Source Type:'		
	Utility	Non-Utility Point Source	Motor Vehicle
Delaware	$1,800	$9,800	$3,200
District of Columbia	$2,100	$3,100	$2,800
Maryland	$1,300	$8,200	$2,900
New Jersey	$1,900	$710	$2,700
New York	$1,900	$6,700	$2,600
Pennsylvania	$1,200	$9,500	$3,200
Northern Virginia	$2,000	-	$2,700

NOTE: [1]Cost per ton for Scenario C2.

Table V-13
Cost per Ton of NO_x Emission Reductions by State and Source Type: Non-OTR Chesapeake Bay Airshed 2 States

State	Cost per Ton by Source Type:[1]		
	Utility	Non-Utility Point Source	Motor Vehicle
Kentucky	$1,100	$6,500	$7,600
North Carolina	$1,100	$5,700	$7,600
Ohio	$1,200	$6,100	$7,400
Tennessee	$1,100	$4,900	$7,800
Virginia (w/o Northern VA)	$1,000	$5,800	$7,600
West Virginia	$1,000	$6,300	$7,500

NOTE: [1]Cost per ton for Scenario E.

CHAPTER VI
RESULTS

This chapter examines the nitrogen load and cost per pound of nitrogen reduced for air pollution controls based on the three scenarios examined (CAA Scenario, Scenario C2, and Scenario E). For comparison purposes, costs for nonpoint source controls are provided in the last section of this chapter.

A. AIR POLLUTION CONTROLS

Using the approach discussed in Chapter IV, along with the emission reduction and cost values presented in Chapter V, the cost effectiveness of air pollution controls was estimated for various source-regions (combinations of geographic areas and emission sources). Table VI- 1 summarizes the estimated reduction in nitrogen load and cost per pound of nitrogen reduced for applying controls in the three Bay States (Pennsylvania, Maryland, and Virginia) as well as for the entire Chesapeake Bay Airshed 2. *Scenario C2* was not examined using *Airshed 2* deposition-to-emission ratios; since controls are concentrated in the Northeast, the effects would be underestimated using average airshed deposition-to-emission ratios. Bay State controls, in the form of OTC initiatives, are about twice as cost effective in reducing nitrogen loads to the Bay tidal waters than non-Bay State controls within the OTC, or controls applied in non-OTC States. For the Bay States, the cost of motor vehicle and major stationary source controls are about equally cost effective in reducing nitrogen loads. Outside the Bay States, utility controls are the most cost-effective, even when applied throughout the entire airshed.

A summary of the nitrogen load reduction and cost for utility and mobile source controls in several States is shown in Table VI-2. The cost per ton of NO_x reduced for utilities is fairly consistent across the States examined. The cost per pound of nitrogen load delivered to the Bay is dependent on geographic location. The Susquehanna and Potomac basins provide the largest atmospheric nitrogen influences to the Bay. The geographic location effect is also observed for mobile sources. The cost effectiveness for applying LEV to the entire Commonwealth of Virginia is significantly higher than the other areas shown, because minimum LEV credits are assumed in areas without enhanced I/M programs. (Appropriate in-use compliance programs are important in ensuring that control technologies continue to meet emission standards throughout a vehicle's lifetime.) Thus, emission reductions are significantly lower (at the same per vehicle cost).

A comparison of the cost per pound of nitrogen reduced, assuming a constant cost for air pollution controls, is shown by source region in Table VI-3. Controls in Maryland are most effective, followed by Virginia and then Pennsylvania. Controls in Eastern Pennsylvania are slightly more effective than those that might be applied in Western Pennsylvania. Outside of these three States, the cost effectiveness decreases by a factor of 2 or more.

Table VI-1
Cost Comparison of Air Pollution Controls by Scenario: Chesapeake Bay States versus Airshed 2 States

	Bay States[1]		Airshed 2	
Scenario	Load Reduced (thousand lbs)	Coat per Pound ($/lb)	Load Reduced (thousand lbs)	Cost per Pound $/lb)
CAA Scenario[2]	5,330	$75	11,570	$123
Scenario C2	6,480	$75	--	--
Scenario E	7,760	$77	17,010	$147
Sector				
Highway Vehicle (LEV)[3]	970	$132	1,700	$329
Utility (0.15 lbs/MMBtu)[3]	5,330	$54	14,610	$95
Non-Utility (0.15 lbs/MMBtu)[3]	180	$396	1,190	$466

NOTES: [1]Bay States represent Pennsylvania, Maryland, Virginia, and the District of Columbia.
[2]Reductions and costs for the CAA Scenario are with respect to 1990 loads and, therefore, incorporate growth, as well as controls. Eliminating the effect of growth would result in higher load reductions and lower costs.
[3]Controls were applied only in the OTR for the Bay States analysis.

Table VI-2
Nitrogen Load Reductions and Costs by State: Utilities and Mobile Sources

Scenario/State	NO_x Reduction (thousand tons)	Nitrogen Load Reduction (thousand lbs)	Total Annual Coat (in millions)	coat Effective ($/ton)[1]	coat Effective ($/lb)[2]	Ratio of $/ton to $/lb
Utility (0.15 lbs/MMBtu)						
Maryland	47.0	1,610	$62.7	$1,300	$39	0.33
Pennsylvania	178.2	3,510	$214.0	$1,200	$61	0.20
Virginia	52.8	1,990	$57.9	$1,100	$59	0.19
West Virginia	155.5	2,240	$157.5	$1,000	$70	0.14
Kentucky	169.1	760	$192.3	$1,100	$254	0.04
Mobile Source (LEV)						
Maryland	13.6	410	$39.0	$2,900	$95	0.30
Pennsylvania	24.1	470	$76.5	$3,200	$164	0.20
Northern Virginia	4.4	90	$11.9	$2,700	$130[3]	0.21
Virginia (entire State)	10.4	220	$558.4	$5,600	$270[3]	0.21

NOTES: [1]Cost per ton of NO_x emissions reduced.
[2]Cost per pound of nitrogen load to the Bay reduced.
[3]LEV associated $/lb estimates are higher in areas of Virginia outside Northern Virginia because expected in-use compliance programs are less stringent.

Table VI-3
Variation in Cost of Nitrogen Load Reduced by Geographic Location

Source Region	Cost per Pound of Nitrogen Load Reduced[1]	
	$2,000/ton NO_x	$1,000/ton NO_x
Airshed 2	$163	$81
Bay States[2]	$87	$44
Maryland	$62	$31
Pennsylvania	$106	$53
East Pennsylvania	$96	$48
West Pennsylvania	$113	$57
Virginia	$86	$43
Kentucky/Tennessee Portion in Airshed 2	$354	$177
North Carolina Portion in Airshed 2	$263	$131
New Jersey/Connecticut/New York City/Long Island	$417	$208
Ohio Portion in Airshed 1	$248	$124

NOTES: [1]The cost per pound of nitrogen load reduced was estimated for each source-region assuming a constant cost per ton of NO_x emissions reduced. The cost per pound of $1,000/ton NO_x controls is one-half of the cost per pound of $2,000/ton NO_x controls. Cost per pound of nitrogen reduced can be estimated similarly for other NO_x control costs.
[2]Bay States represent Pennsylvania, Maryland, and Virginia.

B. VERIFICATION OF METHODOLOGY

Because of the extensive resources needed to complete full RADM and CBWM simulations necessary to fully examine the impact of air pollution controls in alternative geographic areas and for different source types, a simplified approach, or screening method, was needed. The methodology developed for this analysis attempts to develop simplified relationships between emissions, nitrogen deposition, and nitrogen load in order to easily compare the impact of NO_x reductions for various geographic areas and source types.

In essence, source-receptor relationships have been derived from RADM (by EPA) for use in this analysis. There is a certain amount of error introduced in using these relationships. The relationships are also sometimes applied to slightly different geographic areas for the purposes of this analysis. In addition, it was shown in Chapter IV that the load-to-deposition relationships are not linear, and as a result, there will also be some error introduced in using the 1990 load-to-deposition ratios for this analysis.

In order to determine the potential error introduced in applying this technique, an assessment of the impact of Scenario C2 was compared with the load reduction estimated using RADM and CBWM. Table VI-4 shows the expected nitrogen load reduction by State and indicates the source-region for which the deposition-to-emission ratios are based. Using this approach, the estimated nitrogen load reduction is 7,320 thousand pounds. This load reduction is approximately 13 percent higher than the estimated reduction in load based on CBWM results. (The load reduction for the western part of New York may be overestimated).

Using the full airshed source-region, the total reduction in load estimated for the CAA scenario is 11,570 thousand pounds (refer to Table VI-1). CBWM results indicate a reduction of 13,384 thousand pounds. In this case, the nitrogen load reduction is underestimated by almost 15 percent. In this case, the underestimation most likely occurs because emission reductions from sources outside of the airshed are not being incorporated in the simplified analysis.

Table VI-4
Comparison of Scenario C2 Nitrogen Load Reductions by State

		NO_x Reduction (1000 tpy)	Load Reduction (1000 lbs)
Maryland	Maryland	63	2,045
Virginia	Virginia	11	255
Pennsylvania	Pennsylvania	208	3,915
		55	264
State	Source-Region		
New York	NJ/CT/NY-City/Long Island	111	532
District of Columbia	Virginia	2	46
Delaware	Pennsylvania	14	263
Total		464	7,320
Load Reduction Estimated from Watershed Model Results			6,544

C. NONPOINT SOURCE CONTROLS

Table VI-5 provides nonpoint source control strategy cost estimates by management practice in dollars per pound of nitrogen removed. The values shown in this table are in units comparable to the airborne nitrogen reduction scenarios. Note, however, that the full costs of airborne NO_x control measures have been included in the air pollution analysis, without counting the full benefits to other program areas like ozone, visibility, and acid precipitation, or to other geographic areas like the Great Lakes and adjacent East Coast estuaries. The least costly of the Table VI-5 measures are nutrient management, followed by animal waste control. The combination of these two practices removes about 66 percent of the total nitrogen load at about 10 percent of the total cost. The most costly management practice category is the urban category, which removes about 11 percent of the total nitrogen load at about 70 percent of the total cost.

Table VI-5
Cost Analysis Summary by Management Practice for Agreement States: Nonpoint Source - Level of Technology N

Management Practice	"LOT" cost (in thousands)	Nitrogen Load Reduced (1000 lbs)	Percent of Total	Cost of Nitrogen Load Reduced ($/lb)
Urban	$643,172	4,509	10.64	$142.64
Forest	$10,370	150	0.35	$69.13
Farm Plan	$66,169	1,462	3.44	$45.27
HEL[1]	$68,758	2,991	7.05	$22.99
Pasture	$9,015	910	2.15	$9.90
Low Till	$33,285	4,476	10.56	$7.44
Animal Waste	$84,563	11,801	27.84	$7.17
Nutrient Management	$9,812	16,096	37.97	$0.61
Total	$925,144	42,395	100.00	

NOTE: [1]HEL = highly erodible land.
SOURCE: Shuyler, 1995.

CHAPTER VII
CAVEATS AND UNCERTAINTIES

This chapter describes the significant caveats and uncertainties associated with this cost-effectiveness analysis.

1. LEV program cost effectiveness would be much improved with more stringent motor vehicle emission inspection programs outside the OTR Enhanced I/M programs are expected in many areas inside the OTR which makes the LEV program more cost effective there. EPA amended the November 1992 I/M rule recently, which appears to be resulting in some changes in program plans - away from enhanced I/M. No information has been released by EPA about how emission credits for LEV programs might change with new I/M classifications, such as low enhanced and OTR low-enhanced programs.

2. NO_x benefits have been included for Phase II Federal reformulated gasoline. MOBILE5a does not include these benefits directly. These benefits were simulated by an EPA contractor in a way that produces about an 8 percent reduction in highway vehicle emissions in 2000 and beyond in areas that are participating in this program.

3. Some of the areas outside the OTR where the 0.15 lbs/MMBtu NO_x control strategy have been simulated have received NO_x waivers from EPA. This suggests that further NO_x controls in these areas may be counterproductive in reducing ambient ozone levels. If it were assumed that no further NO_x controls would be applied in these areas, then emission reductions and costs would be lower in some of the non-OTR States.

4. In modeling a situation where long-range transport of air pollutants is so important it is difficult to make a fair comparison of costs and benefits. One of the reasons why this problem occurs is because the geographic area where the costs are incurred is not always the same area where the benefits are observed. In expressing the costs of the OTC-LEV petition and the Stationary Source NO_x Initiative, the costs observed in New England States outside the Bay Airshed 2 States have been omitted from the program costs presented in this report, because the benefits of NO_x controls applied in these States are not observed within the airshed. It should also be noted that benefits likely to be observed in watersheds other than the Chesapeake Bay (the Great Lakes, Long Island Sound, and Massachusetts Bay, for instance) have not been used to discount the costs presented here, either.

5. This report includes total program costs of the OTC-LEV petition and the Stationary Source NO_x Initiative in each area (State) in which it would be applied. It is probably appropriate to only report a portion of these costs as attributable to Bay nitrogen reductions, especially those areas where the programs have been initiated as an ozone precursor control measure. Other benefits to the region of reducing airborne NO_x emissions include lower acid deposition rates and reduced secondary particulate formation.

6. The recently completed Ozone Transport Assessment Group (OTAG) 1990 emission inventory contains significantly higher estimates of NO_x emissions than the estimates in the Interim 1990 Inventory. Because the Reference scenario nitrogen loads are based on measurements, the higher NO_x emissions in the base year may not affect total nitrogen loads. If emission estimates by the States are higher because

emission rates were found to be higher in 1990, and emission rate limits are to be met in the future, then scenarios may provide greater reductions in atmospheric nitrogen than have been estimated in this study. However, increasing 1990 emissions may not automatically result in greater reductions in deposition and load via controls, because load-to-deposition ratios will change as well.

7. The CAA baseline NO_x emission forecast was completed in 1994. The forecast may change with imperfect implementation. Since the time of the analysis, several areas have opted-out of reformulated gasoline, and enhanced I/M performance standards have been amended to include low enhanced I/M.

8. This analysis assumes constant ratios between emissions and deposition and between deposition and load. Data were aggregated on a larger geographic basis in order to create a simplified approach for comparing the effects of alternative controls. The degree to which this aggregation effects the estimated reduction in nitrogen load for given NO_x reductions depends on how well these ratios correspond to the geographic location and source type controlled, and on the non-linearity associated with changes in NO_x emissions versus deposition and deposition versus load. Observed (monitoring) data show nitrogen deposition in the northern portion of the watershed to be twice as large as it is in the southern portion. RADM results indicate more evenly-distributed deposition over the watershed.

CHAPTER VIII
CONCLUSIONS

Reducing nitrogen loads to the Bay via air pollution controls is cost competitive with the higher cost nonpoint source control measures such as forest and urban management practices, even without allocating any of the costs to other likely benefits of these programs, such as reducing ozone levels in the Northeast OTR, or reducing nitrogen deposition to the Great Lakes and other east coast estuaries besides the Chesapeake Bay.

As a general rule, NO_x control costs almost double as controls are extended from the Bay States to the entire Chesapeake Bay Airshed 2 States. Further controls of steam-electric utility plants are the most cost effective control measures, even when applied throughout the entire airshed. Requiring cars and light trucks to meet LEV standards outside the OTR is expected to be more cost effective in reducing nitrogen loads than further industrial source controls.

If OTC programs to reduce NO_x emissions are to be extended outside the Northeast OTR the State with the most cost effective emission reductions (cost per pound of nitrogen load reduced) is West Virginia. Controls in other non-OTC States are likely to be less cost effective than improved nonpoint source control management practices.

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APPENDIX A
REGIONAL ACID DEPOSITION MODEL SUMMARY OUTPUT

WORKING SUBDIVISIONS

Absolute Nitrogen Deposition from Source Regions (units=kg-N/ha/yr)

>>>Using 80-km RADM<<<

>>>>AIRSHEDS<<<<	1990 Interim	Basin Portion Above The Fall Line							Basin Portion Below the Fall Line							Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
		(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)
Airshed 1	5,017,195	7.0889	7.0941	12.6658	8.4216	8.7827	7.2511	8.3891	8.3465	4.9932	9.2625	9.645	7.8927	7.8169	11.4613	6.5826
Airshed 2	6,259,342	7.8633	8.0448	13.2259	9.1961	7.3791	8.1197	9.1539	8.9531	5.3693	9.775	10.2288	8.4933	8.2804	11.9823	7.0534
EASTERN UNITED STATES & CANADA	20,671,231	10.0108	10.5087	15.2539	11.6713	8.9504	10.656	11.2251	11.2543	7.737	12.1344	12.3181	10.6558	10.4818	13.7158	9.4023

>>>>CONCENTRIC RINGS<<<<	1990 Interim	Basin Portion Above The Fall Line							Basin Portion Below the Fall Line							Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
Watershed	1,433,636	3.7089	2.9642	9.4131	3.6154	3.22	3.3278	4.9499	5.3215	2.3038	6.3577	6.4514	5.0436	5.2866	8.2864	4.124
Bay States (-) Watershed	319,830	0.5852	0.7217	0.0106	0.5836	0.5021	0.6102	0.5695	0.36	0.2484	0.1887	0.3425	0.2869	0.2427	0.3193	0.1759
Airshed 1 (-) Watershed	3,583,559	3.3799	4.13	3.2527	4.8062	3.5627	3.9234	3.4392	3.025	2.6894	2.9048	3.1936	2.8492	2.5323	3.1748	2.4586
Airshed 1 (-) 3 Bay States	3,263,729	2.7947	3.4083	3.2421	4.4838	3.0606	3.3837	2.8697	2.665	2.4576	2.7865	2.851	2.5623	2.6127	3.1067	2.3646
Airshed 2 (-) Airshed 1	1,242,147	0.7745	0.9507	0.5601	0.7745	0.5964	0.8686	0.7648	0.6066	0.3761	0.5126	0.5838	0.6006	0.4615	0.521	0.4709

>>>>SUBDIVISIONS OF RINGS<<<<	1990 Interim	Basin Portion Above The Fall Line							Basin Portion Below the Fall Line							Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
OH PORTION IN AIRSHED 1	875,615	0.4007	0.5219	0.5439	1.06	0.6871	1.0571	0.3153	0.2497	0.2209	0.4084	0.4589	0.2255	0.3555	0.6152	0.2563
KY/TN PORTION IN AIRSHED 1	509,084	0.3272	0.6416	0.3213	0.5545	0.4772	0.256	0.4986	0.3059	0.1764	0.2854	0.3812	0.3681	0.2228	0.2537	0.2429
NC PORTION IN AIRSHED 2	463,914	1.4234	0.9925	0.3389	0.4284	0.5552	0.121	0.9548	1.1709	0.4391	0.441	0.5459	0.8578	0.386	0.2972	0.6164

>>>>STATE RELATED, ALL SOURCES	1990 Interim	Basin Portion Above The Fall Line							Basin Portion Below the Fall Line							Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
EAST PENNSYLVANIA	434,562	0.4493	0.2396	0.738	0.3777	0.3418	1.2923	0.5594	0.6077	0.5155	0.8275	0.8018	0.8011	0.8353	2.0791	0.7771
WEST PENNSYLVANIA	486,298	0.359	0.6763	0.3353	1.0917	0.5783	1.4247	0.3683	0.2722	0.198	0.322	0.4359	0.2306	0.271	0.8433	0.2108
PENNSYLVANIA	940,038	0.8177	0.9231	1.0996	1.4815	0.9349	2.719	0.9365	0.8869	0.7181	1.1648	1.2459	1.0383	1.1188	2.9256	0.9981
MARYLAND	348,924	0.7636	0.5223	5.9347	1.0925	0.6859	0.6738	1.1227	0.9467	0.7437	3.1912	2.1562	1.3823	2.8922	3.8389	1.6588
VIRGINIA	464,504	2.732	2.2566	2.263	1.3254	2.0646	0.4232	3.3853	3.8027	1.0314	1.982	3.0909	2.8286	1.1736	1.5124	1.5246
3 Bay States (PA,MD,VA)	1,753,466	4.2942	3.6659	9.4237	3.9378	3.7221	3.8674	5.5193	5.6815	2.5356	6.4759	6.7939	5.3305	5.2062	8.3546	4.2179
WEST VIRGINIA*#	471,366	To Be Estimated from West Virginia Utility-Related Values														

>>STATE RELATED UTILITY SOURCE	1990 Interim	Basin Portion Above The Fall Line							Basin Portion Below the Fall Line							Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
Pennsylvania Utilities**	371,711	0.3195	0.5032	0.5208	0.8748	0.4046	1.1441	0.4267	0.3327	0.241	0.4115	0.5014	0.351	0.3106	1.0502	0.2671
Virginia Utilities	70,911	0.2533	0.2175	0.2688	0.1066	0.1641	0.0543	0.6194	0.5212	0.1411	0.2839	0.4566	0.4781	0.1569	0.1858	0.1988
Maryland Utilities	95,896	0.2389	0.1361	0.3242	0.1447	0.2356	0.121	0.3228	0.3307	0.2942	0.857	0.8024	0.493	1.0761	0.5365	0.7223
West Virginia Utilities	307,106	0.1541	0.6401	0.6649	1.238	0.4278	0.4346	0.3818	0.187	0.1334	0.3271	0.2773	0.2433	0.2863	0.5841	0.1885
Kentucky Utilities	330,101	0.1673	0.327	0.1737	0.2697	0.2331	0.1425	0.2509	0.1319	0.0888	0.1443	0.188	0.1770	0.1135	0.1349	0.1175

>>STATE RELATED MOBILE SOURCE	1990 Interim			Basin Portion Above The Fall Line						Basin Portion Below the Fall Line						Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
Pennsylvania Mobile Sces**	315,986	0.2554	0.2455	0.3978	0.4207	0.2996	0.9454	0.3278	0.3096	0.2582	0.4508	0.4425	0.3641	0.4388	1.0799	0.3766
Virginia Mobile Sources	221,106	1.0761	1.0139	1.0696	0.6152	0.9828	0.184	1.4838	1.5152	0.3993	0.8378	1.3416	1.2221	0.4391	0.6484	0.6298
Maryland Mobile Sources	150,613	0.325	0.212	3.2443	0.4931	0.3023	0.3175	0.5538	0.4033	0.3295	1.4027	1.0198	0.5173	0.9239	1.8132	0.5135

>>>>OUTSIDE AIRSHED2 INFLUENCE	1990 Interim			Basin Portion Above The Fall Line						Basin Portion Below the Fall Line						Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
Airshed 2+E SBrd (-) Airshed 2	1,341,758	0.3654	0.2058	0.4344	0.175	0.2202	0.8379	0.3327	0.5924	0.8362	0.8176	0.4491	0.544	0.7439	0.5949	0.6947
NJ/CT/NY-CITY/LONG I.	671,113	0.1551	0.0639	0.2661	0.0717	0.1	0.3644	0.1592	0.3489	0.5911	0.4144	0.2791	0.3423	0.5199	0.3747	0.4685
Eastern Seaboard (E SBrd)	2,665,665	4.1012	2.2436	10.0537	2.5526	2.4555	2.9932	5.1189	6.5174	4.4997	7.4452	7.0646	6.0304	6.5628	8.8125	5.4392

>>>>SOURCE-REGIONS<<<<	1990 Interim			Basin Portion Above The Fall Line						Basin Portion Below the Fall Line						Chesapeake
	NOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
SOURCE REGION	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
Subregion 13 Major Points	267,747	0.2194	0.6382	0.5926	1.4309	0.3561	0.7936	0.3461	0.2066	0.1486	0.3295	0.2912	0.2129	0.2922	0.9345	0.1885
Subregion 13. Area Sources	90,535	Need to rerun - 1990 emissions														
Subregion 20 Major Points	268,962	Need to rerun - 1990 emissions														
Subregion 22 Major Points	300,532	Need to rerun - 1990 emissions														
Subregion 15 Major Points	392,863	Need to rerun - 1990 emissions														
Subregion 7: Major Points	177,686	0.0659	0.0995	0.0635	0.1129	0.0735	0.182	0.0656	0.0427	0.0376	0.0614	0.0725	0.0454	0.0519	0.0748	0.0442
Subregion 7 Area Sources	199,211	0.0528	0.0622	0.0617	0.0968	0.0653	0.1428	0.0544	0.034	0.0295	0.0536	0.0601	0.0388	0.0466	0.0605	0.0379
Subregion 7 Maj Pts+Area	376,897	0.1187	0.1817	0.1252	0.2097	0.1388	0.3248	0.1199	0.0768	0.0671	0.115	0.1326	0.0842	0.0985	0.1353	0.0822
Subreg[illegible] Major Points	216,187	0.0936	0.0867	0.0387	0.0535	0.0434	0.0319	0.0806	0.0933	0.0604	0.0698	0.0588	0.0935	0.0748	0.0563	0.0884
Subr[illegible]9 Area Sources	169,958	0.109	0.0987	0.0375	0.0595	0.057	0.0266	0.0829	0.1038	0.0655	0.0783	0.0634	0.1078	0.0828	0.0559	0.1038
Subregion 39. Maj Pts+Area	386,145	0.2026	0.1854	0.0762	0.113	0.1004	0.0584	0.1635	0.1971	0.1259	0.1482	0.1222	0.2013	0.1576	0.1122	0.1922
Subregion 6 Major Points	120,212	Need to rerun - 1990 emissions														
Subregion 14 Area Sources	157,136	Need to rerun - 1990 emissions														

Explanatory Notes

** I don't quite trust the breakout of the utility + mobile numbers for the Bay States, especially PA, relative to state totals, so we are checking this once again.

*# I think for West Virginia we can ratio up the deposition by the ratio of total-to-utility emissions

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>>>>Clean Air Act Projections<<<	RADM Domain															
>>>>>>Full Projections<<<	East'nU.S &Can			Basin Portion Above The Fall Line						Basin Portion Below the Fall Line						Chesapeake
>>>>>>with 20-km RADM<<<<	IOx EMISSION	APPOMATTOX		PATUXENT		RAPPAHANNOCK		YORK		LOWER EASTERN		POTOMAC		UPPER EASTERN		Bay
	(Tons-NO2/Yr)		JAMES		POTOMAC		SUSQUEHANNA		JAMES		PATUXENT/MID		RAPPAHANNOCK		WEST CHESAPEAKE	TOTAL
		(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg-N/ha)	(kg N/ha)
1990 Interim Emissions	20,671,231	10.2515	11.0659	12.956	11.329	10.6643	11.61	11.1629	12.1581	9.8678	14.1303	11.5403	11.5531	11.3286	13.2262	9.8069
>>(line 104 not a match with line 10)																
		(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)	(% Red'n)
2005 Base CAA	coming	8.14	9.17	13.39	13.6	11.6	16.01	9.81	6.87	9.37	12.96	12.16	8.7	12.6	14.07	9.45
2005 OTC Controls in OTR (C-2)	coming	12.76	12.87	22.45	19.41	17.09	25.33	16.05	11.41	16.52	22.91	20.63	15.05	21.81	23.4	16.58
2005 OTC in OTR C-2/LEV	coming	9.14	9.81	16.68	14.82	12.74	17.73	11.16	7.99	11.38	15.63	14.4	10.2	15.2	17.08	11.37
2005 OTC in OTR C-2/Utility	coming	3.62	3.06	5.77	4.59	4.35	7.6	4.69	3.42	5.14	7.28	6.23	4.85	6.61	6.32	5.21
2005 OTC Controls in Airshed2	coming	33.62	35.6	41.93	48.17	41.91	49.8	37.17	28.47	31.12	41.68	40.93	32.96	38.98	43.26	32.51
2005 OTC Controls in Airshed+OTR	coming	33.79	35.9	42.16	48.25	42.05	50.12	37.36	28.83	31.86	42.03	41.2	33.34	39.59	43.56	[illegible]
2005 Lim of Tech(LOT)(Strategy E)	Coming in October															

Updated 12MAR1996 MMS & RLD